Getting retting better by bacterial blending

Jute is the second most important fibre crop after cotton. Harvesting of jute is followed by retting, where the fibres are separated from stems. This is performed in open waters where natural microorganisms decompose the plant material. The fibre quality depends on retting efficiency. Given the water scarcity in Bangladesh and the resulting delays in harvest, the quality of fibres deteriorates. To hasten the process, the Basic and Applied Research on Jute (BARJ) Project at Bangladesh Jute Research Institute under the leadership of Professor Maqsudul Alam have recently identified pectinolytic bacteria that enhance jute retting. This improved retting technology will enable the production of large-scale high quality jute fibres.

Jute is an important cash crop in Bangladesh, where it is cultivated and processed for its fibres. Following jute harvest, the plants go through a process called retting whereby the stalks are submerged in water bodies. This allows natural decomposing of the stems via water-based microorganisms, to release fibres. The microorganisms in the water bodies possess enzymatic activities that enable the digestion of tough plant materials. Unfortunately, the scarcity of water in Bangladesh results in harvesting delays, forcing the farmers to use the same water bodies for retting repeatedly, resulting in poor quality jute fibres. To hasten the water retting process and enhance its efficiency, alternative procedures are necessary. A team in the BARJ project have recently discovered a consortia of bacteria that act efficiently to digest jute stalks and release fibres. This environmentally friendly technology can be used in industrial scale retting to improve jute fibre quality.

NATURAL DIGESTION

Microorganisms are around us everywhere, in the form of microscopic life such as bacteria, fungi, and viruses, to name a few. There are some good ones and bad ones, depending on the microorganism and what it affects.

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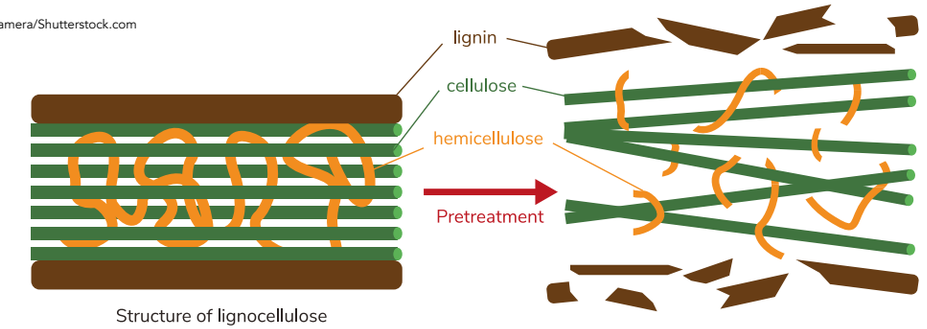

Structure of lignocellulose

Disrupt structure of lignocellulose from pretreatment process

Retting is the process by which unwanted compounds (such as pectins and hemicelluloses) are removed from jute stems.

In a teaspoon of soil, there is thought to be more than one billion bacteria. These bacteria could be harmful or helpful, depending on the plants that grow in the soil. Similarly, in water bodies, there are many bacteria that help degrade organic matter such as plants.

Natural decomposition of organic plant matter occurs in the environment with the help of microorganisms. This is a process which is essential for the recycling of carbon, nitrogen and other nutrients in the ecosystem. Decomposition of plant material requires the chemical activity of microorganisms. Bacteria release numerous enzymes (specialised proteins) that act on specific complex substances present in plants to break them down into smaller particles. These smaller particles are then either consumed by the bacteria to help them reproduce or recycled back into the ecosystem. If more organic matter is fed into the ecosystem, then the bacteria rapidly multiply and increase in number as they decompose the plant. This digestion of organic matter is not only useful for the microorganism, but it can also be useful for processing of plant material for manufacturing purposes. This is taken advantage of in the jute processing industry.

LETTING RETTING WORK

Once jute plants are harvested, an important process is to separate the jute fibres from the stems, in a process called retting. After retting, the fibres are subsequently removed from the stems, washed, dried, and then used to manufacture various jute products. Retting is important because it is the first downstream step after harvesting of the crop, which is important to initiate the whole fibre extraction process.

Jute fibres are embedded in the structure of the jute stem with the help of various structural compounds that are complex carbohydrates. Carbohydrates such as pectin, hemicellulose and cellulose are important constituents of plant cell walls that give strength and shape to the stem. For the jute fibre to be useful, it needs to retain the strengthening properties of cellulose and another compound called lignin, but be devoid of pectins and hemicelluloses, as well as sticky substances that cement the fibres together. Retting is the process by which these unwanted compounds are removed from jute stems.

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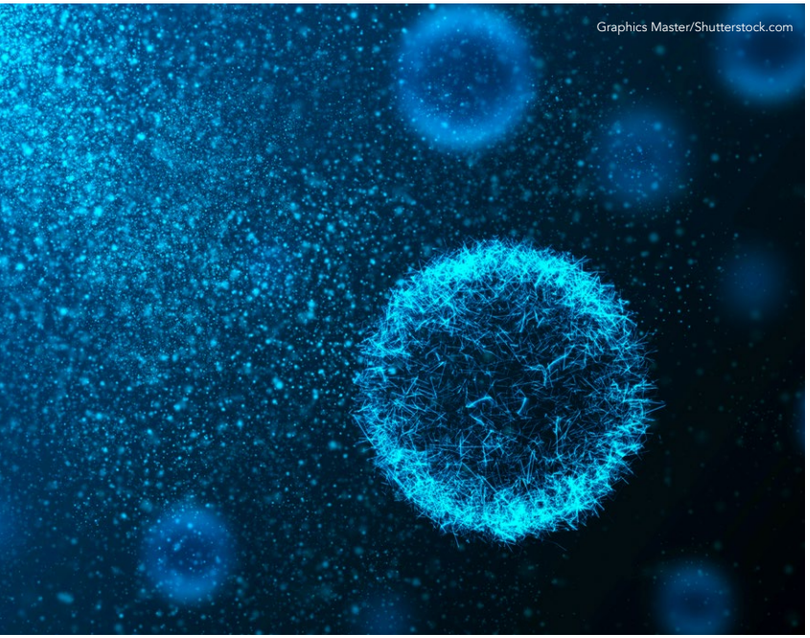

BARJ Project identified potential retting microbes from retting liquor.

Retting can be carried out either by chemical, water-based microbial, enzymatic or dew methods. Of these, apart from the water-based method, the other processes use toxic chemicals or are very expensive. Getting the efficiency and timing of retting perfect is not easy, yet it is the most important step that determines the quality of the fibre. Over-retting or under-retting of jute results in fibres that are rough, lack lustre and not as strong as they should be. This proves to be damaging to the jute industry.

The water-based method of retting is dependent on the activity of microorganisms that live in the water body. These microorganisms release enzymes such as pectinases (that breakdown pectin) and xylanases (that breakdown hemicellulose); this digestion of plant cell wall compounds releases jute fibres from the stems. However, given the scarcity of water resources in Bangladesh, farmers tend to reuse the same water bodies for retting. This depletes the water of its microorganisms, mainly bacteria, thereby making the water of poor quality for the purpose of retting. Retting would have to proceed for longer times, therefore resulting in fibres that are not of very good quality. There has been an urgent need to identify new methods to make the retting process more efficient, cost-effective, and environmentally friendly.

This technique using retting microbes can now be used in large-scale industrial processes, without damaging the environment with toxic chemicals.

RETTING WITH BACTERIAL BLENDING

In recent work, the BARJ Project at Bangladesh Jute Research Institute investigated bacterial populations in different jute retting water samples in Bangladesh. They studied the digestive properties of various isolated bacteria, in particular their pectinase, xylanase and cellulase (digests cellulose) activities. The enzyme activities were first tested on artificial substrates (pectin, hemicellulose and cellulose) in the laboratory. Bacteria which contained pectinase (pectinolytic bacteria) and xylanase activity, but were devoid of cellulase activity were considered to be efficient digestors for the purpose of microbial retting. A total of 451 bacterial isolates were identified in these water samples using molecular biological approaches. From these, the authors then tested combinations of ten different bacterial isolates to investigate whether bacterial consortia possessed better enzymatic activity than individual bacteria. After testing the enzyme activity on artificial substrates, the bacteria were tested with jute samples to check their ability to digest plant material.

Three combinations of pectinolytic bacteria were identified that lowered the retting duration from 18-21 days to 10 days, and also yielded high quality jute fibres in small scale and large-scale experiments. The process resulted in fibres that had improved strength, colour and quality. The study therefore identified a novel method of using bacterial consortia to facilitate jute retting using a water-based approach. This technique using retting microbes can now be used in large-scale industrial processes, without damaging the environment with toxic chemicals.

In a country where water is precious and timing of crop harvest is critical for a farmer's livelihood, hastening the process of jute retting through this novel microbial technique will accelerate the quantity, and increase the quality of jute fibres.

Research Objectives

Acute shortage of water and environmental pollution created from the conventional methods of jute retting demands for improving the retting process. The aim of this work was to optimise our microbial retting protocol to lower the retting period with limited water and to increase fibre quality.

References

Hasan, R., Aktar, N., Kabir, S.M.T. et al. (2020) Pectinolytic bacterial consortia reduce jute retting period and improve fibre quality. Nature Scientific Reports, 10, 5174. https://doi.org/10.1038/s41598-020-61898-z

Personal Response

How soon can this process be adapted for application in the field?

" Before any process can be applied to the field it must be economically viable, socially acceptable as well as environmentally friendly. Considering these factors, we are developing a package which is easy to use at a marginal farmer's level. We are testing different cheap materials such as rice bran, sugarcane husk, wheat bran, etc., which can be used as an effective carrier substance for long term storage of the consortia. We are going to a large scale field trial using consortia under farmer's fields in new and challenging situations. It will take 2–3 jute growing seasons to complete a technology package for marginal farmers. "

Can traditional methods be changed easily to adopt this process?

" The traditional retting method of jute has been universally practiced since the initiation of jute cultivation. So farmers may not agree with a change in the method they know and practice and which they see working. Why would they pay money for something they don't know? We aim to apply the technology practically in front of them and let them see with their own eyes how much more benefit they can get with such an application. Compared to the traditional approach, our novel method of using bacterial consortia is more effective in terms of reduction of retting period with minimum amounts of water and improved fibre quality. It is expected that farmers in the area of water scarcity will show their interest to accept this new process easily. "